Intelligent Repair Systems

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ABSTRACT

Tactical Wheeled Vehicles provide supplies, parts, and people to the field in support of combat missions. It is essential to the Army that an operation ready fleet is maintained. This mission readiness can be greatly increased by analyzing targeted data through use of intelligent vehicle repair systems. Many vehicles have been electronically upgraded to provide improved diagnostic information. However, this information is not widely leveraged from a vehicle or fleet wide perspective. The institution of integrated solutions that allow for condition based maintenance will provide commanders and operators with up to date vehicle status, performance, and repair information thereby decreasing a vehicles downtime in the field. An integrated prototype solution that enhances vehicle maintenance by providing immediate fault detection and intelligent repair information is currently being developed. This system lays the groundwork for the development of prognostic algorithms within future platforms.

INTRODUCTION

Relevance to Mission Readiness

The US Army intends to make extensive use of prognostics and diagnostic technology on weapons platforms, support vehicles, and even munitions. The Army transformation is driving this move toward embedded prognostics. The Chief of Staff of the Army has initiated the Army transformation to bring about fundamental changes in the Army's structure, equipment, and doctrine. These changes are needed to align the Army with radically different mission requirements. A new Army Vision has been established to create a fighting force that achieves victory through superior striking speed, agility and mobility rather than massed power. This level of responsiveness is enabled by information and communication technologies that provide all echelons of the fighting force with real-time situation awareness and rapid reaction capabilities. The ability to react much more rapidly than the enemy is one of the keys to achieving a decisive victory across the full spectrum of operations. The Army's key transformation goal is to reduce the logistics footprint in order to enhance the sustainability, deployability, readiness, and reliability of military systems [1].

Currently, legacy systems have limited Geographic Information Systems (GIS) and no advanced diagnostics capability integrated that would allow for fleet monitoring to include condition based maintenance. Therefore, operational failures occur without warning as they develop in theater. In order to increase vehicle system reliability, and consequently mission effectiveness, the Army needs to address the repair and replacement of vehicle components based off targeted data collection and advanced diagnostics algorithm applications. The journey toward advanced diagnostics integration within Tactical Wheeled Vehicle fleets can only be realized through development of an integrated solution that can seamlessly retrofit legacy fleets. This concept would aid the vehicle operator crew in the early recognition and repair of vehicle systems prior to component failure via an in-vehicle display screen utilizing emerging imaging solutions to locate troubled vehicles and coordinate distribution of supplies, parts, and people [2].

SOLUTION

OVERVIEW

An intelligent repair system is the combination of onboard systems that provide data, faults codes, vehicle history and repair information. These systems are combined in an on-board computer that assimilates as much information as possible and presents the most likely repair options to vehicle operators and maintainers. This system will identify problems as quickly as possible and will reduce damage that results from running vehicles with damaged systems and sub-subsystems.

Figure 1: On-Board Computer Example

The intelligent repair systems will also reduce troubleshooting and maintenance time by identifying the

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14. ABSTRACT
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most likely causes of the detected problems. This system improves condition based maintenance through the early identification of system problems and uses component replacement information to better predict when components will begin to show problems. All of these factors combine to maximize vehicle maintainability and readiness.

INTELLIGENT REPAIR SYSTEM

Components

At its core the Intelligent Repair System depends on the following components:

- The on-board computer and its data collection software.
- Information reported from vehicle ECU's (Electronic Control Units).
- OEM provided repair and fault code information.
- Operator provided repair information.
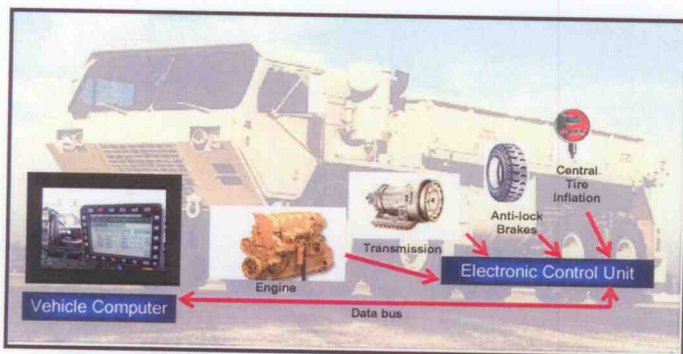- Algorithms used to present repair steps.

Figure 2: Vehicle data bus collection system

Data Collection

In the early 90's, the Society of Automotive Engineers (SAE) Truck and Bus Control and Communications Sub-committee started the development of a CAN-based application profile for in-vehicle communication in trucks. They developed a set of specifications for protocol broadcasted data and data rates which became known as the SAE J1708 standard. Diagnostic Trouble Codes, or DTC's, information is primarily maintained on the J1708 network which provides for automatic and requested DTC information.[1].

In 1998 SAE further expanded the capabilities of diagnostic systems when they published the J1939 standard which is a superset of the J1708 defined protocol data specification, and its design supports SAE class A, B, and C communication functions. This new J1939 specification - with its engine, transmission, and brake message definitions - was dedicated to diesel engine applications [2]. With the incorporation of an electronically controlled engine and transmission into the Army's HEMTT (Heavy Expanded Mobile Tactical Truck)

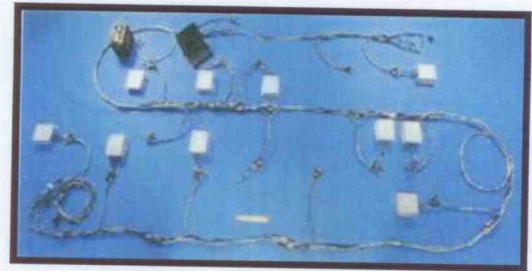fleet, the J1708/J1939 standards for, DTC's (Diagnostic Trouble Codes) were thereby adopted by the military.

Figure 3: Twisted Pair J1939 Data Bus

Some vehicles also employ ECU's for Anti-lock Brakes Systems (ABS), Central Tire Inflation Systems (CTIS), and other vehicle systems. Communication systems designed according to J1939 standards are EMI/RFI tolerant, free of connection wires, easy to install, and feature log, record, remote access, and self-diagnosis capabilities.

Both network protocols are SAE defined and J1939, the newer protocol, represents a superset of J1708 data. The faster J1939 network is considered a control network while the slower J1708 network is considered a diagnostic bus. Most data is broadcast over the network at protocol defined rates. These rates vary from minutes to seconds to milliseconds. Some data is transferred at variable rates dependent on conditions and some data is by request only. The Intelligent Repair System will depend mostly on the broadcast parameters but will sometimes utilize request based parameters to attain more in depth information.
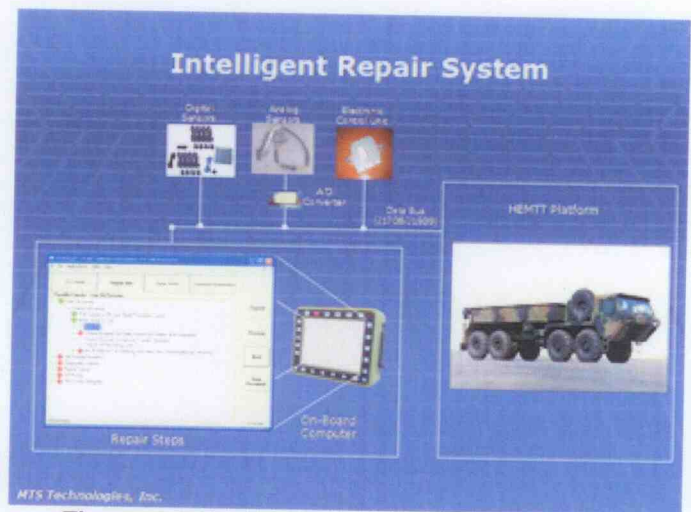

Figure 4: Intelligent Repair System Overview

The Intelligent Repair System will connect to the vehicle network through a vehicle network adapter. This hardware can be a built into the on board computer or can be external to the computer. Many adapters support a well known API for handling the software connection to the vehicle, the TMC RP1210a. This Recommended Practices API allows the repair system to operate on any

adapter hardware that supports the RP1210a API. The API delivers logical protocol messages to the application layer software and is also capable of transmitting literal protocol messages back on to the vehicle networks. The Intelligent Repair System hardware monitors the network data as it flows over the vehicle network and identifies newly reported DTC's as soon as they are reported by the vehicle's ECU's.

OEM Provided Information

The original equipment manufactures (OEMs) have available a vast array of information on the components that comprise their systems. Among this information are the following elements that are central to the Intelligent Repair System:

- Reported Diagnostic Trouble Codes and their Failure Mode Identifiers (FMIs).
- Troubleshooting and Repair step information as related to specific DTCs and FMIs.
- Component expected failure and maintenance times.

All of the above information is used by the Intelligent Repair Systems algorithms or weighting schemes to present the most likely repair step to vehicle maintainers.

Operator Provided Repair Information

The Intelligent Repair System is capable of using operator or maintainer provided repair information in its repair information algorithms. The system is also capable of determining when and if a particular repair has been made by the maintainer. When a DTC is present on the network the only way that it can be cleared from active status is by the maintainer or the controlling ECU. In either case, when a DTC is reported as cleared or repaired the system prompts the maintainer for maintenance and or repair information. In some cases no action will have been taken, in others the operator will select the best starting and ending repair steps used to repair the DTC. This repair history will be logged for future operator use and algorithm input.

Maintainers also perform non-DTC related vehicle maintenance that can be entered into the vehicles component monitoring log. This allows the Intelligent Repair System to track component usage and replacement schedules. This information can then be used to accurately determine component lifespan and enable condition based maintenance.

Repair Step Algorithms and Presentation

The OEM provided repair steps and troubleshooting information is tied to specific DTCs and perhaps specific performance data but its presentation is not typically dynamic. The Intelligent Repair System uses the various inputs, described earlier, to present the information in a

dynamic weighted fashion. This allows maintainers to make quicker and more accurate repairs decisions.
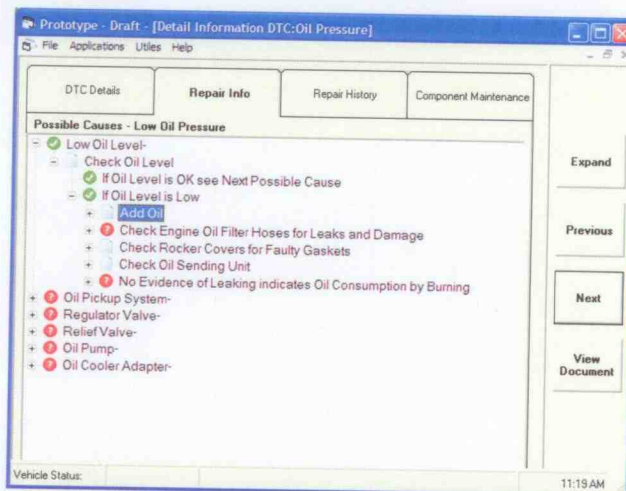

Figure 5: Operator Screen - Repair Information

DTC information is detected and stored in the OBC DTC database. This information is already linked to OEM repair information, DTC history, possible failed components and individual vehicle and DTC repair history.

The most likely problem or cause of the failure is first assigned OEM ordering as originally provided. DTC history is examined to determine if this DTC has occurred in the past and which repairs were ultimately used to correct the problem. Component lifespan logs are then checked to determine which components are closer to their expected replacement or failure times. This information is constantly maintained by the system as it monitors such items as mileage, speed, engine hours and idle hours. The analysis algorithms combine all of this information and assign an augmented weight to the repair step likelihood. The algorithms suggested repair choice is then maintained throughout the repair process in order to compare it with the actual repair performed.
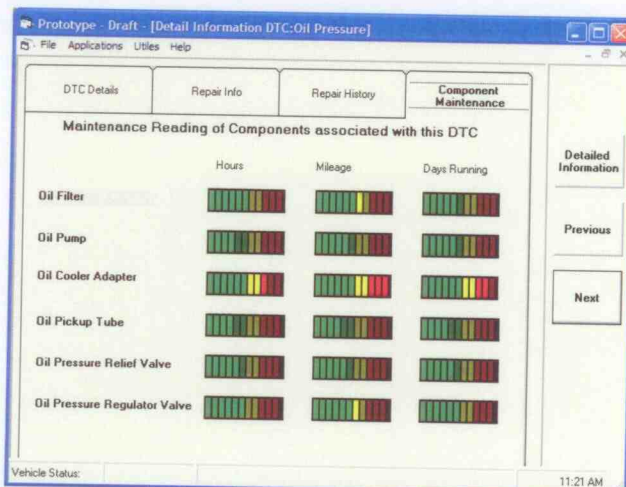

Figure 6: Operator Screen – Component Information

CONCLUSION

It is vital to the Army that an operation ready fleet is maintained at all times. This mission readiness can be greatly improved by analyzing targeted data through the use of intelligent vehicle repair systems. Many vehicles have been electronically upgraded to provide improved diagnostic information, however; this information is not widely leveraged from a vehicle or fleet wide perspective.

The intelligent repair system discussed in this paper is a combination of onboard systems that provide data, faults codes, vehicle history and repair information to the soldiers on a real-time basis. These systems are combined in an on-board computer that assimilates as much information as possible and presents the most likely repair options to vehicle operators and maintainers. This system will identify problems as promptly as possible and will reduce damage that results from running vehicles with damaged systems and sub-subsystems. The intelligent repair systems will also reduce troubleshooting and maintenance time by identifying the most likely causes of the detected problems. This allows for condition based maintenance that will provide commanders and operators with up to date vehicle status, performance, and repair information thereby decreasing a vehicles downtime in the field. In short, this system lays the groundwork for the development of prognostic algorithms within future platforms.

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